just as fresh matter is hourly brought to the earth by meteors, it steadily loses during its orbit in the solar system some of its gaseous constituents; and the near maintenance of a *status quo* during ages partly depends upon the circumstance that gain and loss balance each other, and partly also upon the gain and loss, during the record of mankind, being so infinitesimally small in proportion to the gaseous and fluid matter surrounding the lithosphere of the earth. But during the geological ages even this "little" may be appreciable: long periods may have passed when the gain has been in excess, which has caused a rise in the volume of the sea; whilst at others the loss has predominated, whereby a gradual fall of the sea-level has taken place.

That the atmosphere sometimes decreases through loss in space it is of course impossible to demonstrate by direct observation; but as we at present know fairly well the forces acting upon a gas or dust molecule in the outer strata of the atmosphere, it seems that we may, from a theoretical point of view, be able to obtain an answer to the question raised here. However, we must, to avoid erroneous and hasty conclusions, here take into consideration so many factors difficult to estimate that the definite answer probably for a long time will give rise to much controversy.

Therefore, although the problem of the rising of the land on the coasts of Sweden and Finland may now be said to have, in the main, been decided, the old question about the diminishing of the sea-level, and that just in the general form in which it was presented by Swedenborg and Linnæus, still remains an unsolved riddle of immense importance to the history of our earth.

A. E. NORDENSKIÖLD.

VARIABLE STARS AND THE CONSTITUTION OF THE SUN.

VARIABLE STARS.—The theory of variable stars set forth by Dr. Brester in a recent essay[1] somewhat resembles those suggested by Zöllner in 1865,[2] and by Dr. Lohse in 1877.[3] Briefly, Zöllner's theory regards variability as being due to the formation of scoriæ on the photospheres of the stars and their subsequent dispersion by the heat due to chemical combinations which take place in virtue of reduced temperature. Dr. Lohse substitutes absorption by the cooled atmospheres of the stars for the reduction of light by scoriæ as in Zöllner's theory, although both agree as to the cause of the removal of the light-obstructing agencies. The theory suggested by Dr. Brester is a little more ambitious than either of these, and, to give a translation of his own statement, "All the phenomena that variable stars present to us are the varied effects of one cause—the intermittent chemical combination at the cool external layers of that which had previously been dissociated by heat" (p. 1). All the explanations are based on the assumption that the stars are stratified spherical agglomerations of gaseous matter, the different layers having different compositions according to their distances from the centre.

Most stars are too hot to allow of the formation of compounds as we know them, but the stars most subject to variability (the red stars) are sufficiently cool, in their outer layers at least, for the formation of such compounds as hydrocarbons. It is in the obstruction of light by these compound vapours that Dr. Brester finds his explanation of variability. He aptly compares the cooling of a star to the running down of a clock-spring, and the intermittent chemical combination to the escapement which regulates it. These changes pass unnoticed in the hottest stars, because the periods elapsing between the coolings is very great, and the combinations formed exert no very great absorbing influence; but in the cooler stars only small changes of temperature are necessary, and the periods are correspondingly short.

Again, although the temperature may be low enough for a combination to take place, the combining substances may be so diluted by other matter that the combination is impossible, just as a mixture of oxygen and hydrogen will not explode if admixed with more than 7½ volumes of air (Bunsen). This condition Dr. Brester describes as a state of *surdissociation*. This state does not last long, because, as the combining molecules get nearer the centre, they get more concentrated, while the substances which prevent their union diminish in proportion. When the combination does take place, there is an "eruption of heat" and the clouds in the outer cool layers are dispersed, the brightness of the star consequently increasing.

So much for the general theory, which Dr. Brester believes to be competent to explain every description of variable star, even such diverse ones as Algol and β Lyræ. He rejects the eclipse explanation of the Algol type on the ground that it is impossible to conceive such large obscure bodies to travel at such an enormous rate, and that it is in contradiction to the recent work of Chandler and Sawyer, showing irregularities in the periods, especially in the case of U Ophiuchi.

Secondary maxima, such as occur in β Lyræ, he believes to be due to double combinations: the first substances which combine by the fall of temperature do not produce sufficient heat to reproduce the first maximum, whereas the next combination does, and these taking place alternately, the β Lyræ type receives explanation. Irregularities in the variability are, according to this theory, due to disturbances brought about by very rapid rotations.

"New stars" are believed by Dr. Brester to be produced by the sudden dispersion of the obscuring clouds which formerly surrounded the star, by heat due to a new chemical combination. On this supposition they must be at a very low temperature before they burst out. It is not easy to understand, however, how any such action as this could raise a star from the ninth to the second magnitude, as was the case with T Coronæ. The spectroscopic difficulty is a still greater one. How the spectrum of a new star just before its disappearance could, on Dr. Brester's view, be like that of a planetary nebula, is not easy to explain. For the present it seems more consistent with the facts to regard "new stars" as being due to the clashing together of two meteor-swarms in space.

In this theory Dr. Brester has attempted too much. Most astronomers are agreed that more than one cause of variability is at work, and it is certainly too much to expect one theory to explain all the various types. Dr. Brester does not seem to be aware that Algol is one of the hottest stars in the heavens, and that a recent photograph by Prof. Pickering shows the spectrum to be the same at maximum as at minimum. If one hot star be variable, why not all? Again, if variability is only manifest in the cooler stars, why does not every cool star give indications of variability? Further, the theory assumes that all variable stars are cooling, whereas Mr. Lockyer's recent work has shown that those of the Mira type are increasing in temperature. Dr. Brester's only objection to Mr. Lockyer's theory of variability is its limited application, but it was not set forth as being universally applicable. If Dr. Brester's theory had been limited to the variables of Group VI. (Vogel's Class III*b*), it would be more reasonable, but even then it would not be easy to understand why all the stars of the group do not exhibit variability.

The Sun.—The second part of the essay attempts to explain the various phenomena presented to us by the

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[1] "Essai d'une Théorie du Soleil et des Étoiles variables," par A. Brester, D.Sc. (Delft: J. Waltman, 1889).

[2] "Photometrische Untersuchungen," p. 252.

[3] *Monatsber. der Akad. der Wissenschaften*, p. 826.

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sun. The first great departure from prevailing opinions is the view that the sun is in a tranquil state, and is in no way subject to the violent storms which are commonly believed to disturb it. The stratified character of the solar atmosphere is set forth as evidence of this tranquil state. Dr. Brester believes that the apparent motions of the protuberances are not real, but simply indicate the displacement of the luminous condition brought about by chemical combinations in tranquil matter. This he believes to be quite consistent with the observed displacements of the prominence lines, and we see no reason to differ with him.

The next important divergence from prevailing ideas is the suggestion that pores, spots, and faculæ are all at exactly the same temperature because they are at the same level. The experiments of Spoerer and Langley have shown that the spots emit less heat than the other parts of the photosphere; but Dr. Brester states that this is not due to a difference in temperature, but to a difference of emissive power. He believes that spots are formed by the vaporization of the photospheric matter in the regions where they are formed, the luminosity being reduced, whilst the temperature remains the same. On this supposition, the photosphere bears the same thermal relation to the spot that ice does to the water formed as it melts.

The forms of the spots he believes to be due to the increase of pressure caused by the volatilization of the photospheric matter, the conical form being due to the fact that the nearer the centre the greater the resistance to the expansion.

That faculæ should precede spots Dr. Brester states to be essential to his hypothesis. They indicate the places where increased condensations are taking place prior to the "eruptions of heat" which will produce spots.

For an explanation of the periodical phenomena, and the increased angular velocities of spots near the equator, Dr. Brester assumes that, while the photospheric surface which we see is spherical, the different layers of the atmosphere must be ellipsoidal, owing to the rotation of the sun. He admits that this state of things is not easy to explain, but states that it is sufficient to know that the fact exists. This being taken for granted, the varying periods of rotation in different latitudes is not difficult to explain. For since the photospheric matter is formed by the condensation of the vapours of the ellipsoidal layers, the particles in equatorial regions have to descend a greater distance towards the centre than those in the same layers near the Polar regions; and since the linear velocity remains the same during the descent, the angular velocity is increased, and is increased more at the equator than away from it. Since the spots lie in the photosphere, they thus indicate an increased angular velocity in equatorial regions. It will be seen that this explanation is much akin to that suggested by Mr. Lockyer,[1] differing from it mainly in giving the whole photosphere the additional velocity, whereas, according to Mr. Lockyer's view, only the spot-forming material partakes of the added angular velocity.

The relation of spot spectra to the eleven-yearly period observed by Mr. Lockyer is also partially explained. According to Dr. Brester's view of the solar economy, the photosphere must have a special composition in each latitude, and since the latitudes of the spots vary with the period, the spectra would also vary with the period. The exact nature of the change—namely, from lines of iron and other known substances at minimum to unknown lines at maximum—is not explained.

The similarity of the spot zones on both sides of the equator, according to Dr. Brester's view, is due to the fact that the same atmospheric layer meets the photosphere in equal latitudes on opposite sides of the equator. The slight differences which do exist are regarded as simply the effect of chance, since an "eruption of heat" may either produce one large spot or several smaller ones.

Dr. Brester also attempts to explain the cause of the eleven-yearly period, but his explanation is difficult to follow. Broadly speaking, his idea is that during eleven years the integrated effects of the various chemical combinations which have taken place are such as to very nearly restore the conditions which had existed at the commencement of the period. Slight differences would be produced each time, so that after a long interval, well-marked differences might be expected.

Although the theory explains many of the phenomena observed, an explanation of many more is still required. Thus, although it is not difficult to understand the absence of spots at the equator, the cooler layers there being at the greatest distance from the photosphere, we should be led to expect the greatest number of spots in polar regions, where the atmosphere in the neighbourhood of the photosphere is coolest, and where, therefore, chemical combinations would be most likely to take place. The question of the corona is reserved for a future essay, but Dr. Brester is confident that it will present no great difficulty. He also hopes to satisfactorily explain the phenomena of comets' tails, the zodiacal light, and the variability of Jupiter and his satellites.

In conclusion, Dr. Brester states that his theory, so far from being at variance with the laws of chemistry and physics, really strengthens them, and that it is not discordant with the observed facts. At the same time he admits that the difficulty of comprehending it in detail will prove a great drawback to its acceptance.

A. FOWLER.

THE RABBIT PEST.

MR. W. RODIER, of Tambua, Cobar, New South Wales, has forwarded to this Society a printed sheet, containing, as it appears to me, by far the best suggestion yet made for the extermination of rabbits—a subject to which my attention has been repeatedly called by various correspondents in the Australian colonies, where, as is well known, the damage done by these animals is enormous. Mr. Rodier states that his plan has been in operation at his station in New South Wales for about eight months "with the utmost possible success," and has cleared the country of rabbits. It is a very simple plan. Ferrets and nets are used in the usual way to capture the rabbits, but while all the females taken are destroyed, the males are turned out again uninjured.

The results of this mode of operation are that the male rabbits, as soon as they begin to predominate in numbers, persecute the females with their attentions, and prevent them from breeding. They also kill the young rabbits that happen to be born; and even, as Mr. Rodier asserts, when they largely predominate in numbers, "worry the remaining does to death."

This is all strictly in accordance with what we know takes place under similar circumstances in the case of other animals, so that we can readily believe it to be likely to happen.

The ordinary mode of trapping, as Mr. Rodier points out, is more likely to increase the number of rabbits than to diminish them. For reasons which he clearly explains, more buck rabbits are always killed by the trappers than does. Thus the does predominate in numbers, and, a few bucks being sufficient for a large number of does, are perpetually breeding and increasing the stock.

The plan advocated by Mr. Rodier is so simple and easy that I cannot doubt it will be widely followed when known. No disease that might otherwise cause injury is introduced, no other noxious animal is proposed to be

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[1] "Chemistry of the Sun," p. 424.

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